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Indian Standard

METHODS OF MEASUREMENTS FOR AMPLITUDE MODULATED RADIO FREQUENCY SIGNAL GENERATORS
(30 kc/s TO 30 Mc/s)

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 6 *May* 1963

Indian Standard

METHODS OF MEASUREMENTS FOR AMPLITUDE MODULATED RADIO FREQUENCY SIGNAL GENERATORS

(30 kc/s TO 30 Mc/s)

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Indian Standard

METHODS OF MEASUREMENTS FOR AMPLITUDE MODULATED RADIO FREQUENCY SIGNAL GENERATORS

(30 kc/s TO 30 Mc/s)

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 14 January 1963, after the draft finalized by the Electronic Equipment Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard prescribes the conditions and detailed procedures for the tests to be conducted on all classes of amplitude modulated (sinusoidal modulation) radio frequency signal generators covering a frequency range of 30 kc/s to 30 Mc/s to determine their performance characteristics. However, the methods of measurements included in this standard, may be adopted for frequency ranges higher than 30 Mc/s with suitable instruments and accessories.

0.2.1 The tests prescribed in this standard apply only to complete signal generators; separate consideration for the component parts has not been given in this standard.

0.3 This standard covers methods of measurements primarily for the measurement of frequency, output and modulation of signal generators as well as other characteristics such as residual output voltage, carrier level shift due to modulation, distortion, unwanted modulation and leakage.

0.4 This standard lays down a single method of measurement for each characteristic so as to achieve the required degree of precision. It is, however, not intended to exclude other alternative methods of measurement for which necessary measuring equipment may be available and which are of equal or greater precision than the method prescribed in this standard. Such alternate methods, wherever necessary, have been given in Appendices A, B and C.

0.5 Though the methods specified in this standard for measurement of leakage are quite adequate, the Sectional Committee responsible for the preparation of this standard has taken up the examination of the method given in IEC Publication 106 Measurement of Radiation from Radio Receivers, with a view to adopting the same later on.

0.6 The requirements of various classes of signal generators are proposed to be covered in a series of standards, the first among them being IS : 2321-1963 Requirements for General Purpose Amplitude Modulated Radio Frequency Signal Generators (30 kc/s to 30 Mc/s).

0.7 In the preparation of this standard, assistance has been derived from the following:

DOCUMENT 13C (SECRETARIAT) 7 IEC RECOMMENDATIONS FOR SPECIFICATION OF THE RADIO FREQUENCY SIGNAL GENERATORS. International Electrotechnical Commission.

DOCUMENT 13C (SECRETARIAT) 8 IEC RECOMMENDATIONS FOR AMPLITUDE MODULATED RADIO FREQUENCY SIGNAL GENERATORS. International Electrotechnical Commission.

NFC 42-600 : 1957 MEASURING INSTRUMENTS HIGH FREQUENCY GENERATORS, MODULATION OF AMPLITUDE. I' Association Francaise de Normalisation.

UNITED KINGDOM. MINISTRY OF SUPPLY. Report No. REMC/24/FR Issue 2, January 1958. Joint Service Standards and Recommendations for Signal Generator Calibration, issued by Radio and Electronic Measurements Committee.

0.8 In reporting the result of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960 Rules for Rounding Off Numerical Values (*Revised*).

0.9 This standard is intended chiefly to cover the technical requirements relating to measurements on signal generators, and it does not include all the necessary provisions of a contract.

---

1. SCOPE

1.1 This standard lays down the conditions and detailed procedures for the tests to be conducted on all classes of amplitude modulated (sinusoidal modulation) radio frequency signal generators in the frequency range of 30 kc/s to 30 Mc/s to determine their performance characteristics.

1.1.1 These tests apply to complete signal generators only and not to component parts thereof.

2. TERMINOLOGY

2.0 For the purpose of this standard the following definitions and explanation of terms shall apply.

2.1 General

2.1.1 *Magnitude of Sinusoidal Voltages and Currents* — Shall mean RMS values, unless otherwise specified.

2.1.2 *Mains Operation* — Operation of the instrument from a power source with an operating voltage over 24 V, not solely used to supply power to the instrument.

2.2 Signal Generator — Source of radio frequency energy of accurately known characteristics and capable of modulation.

2.2.1 *Amplitude Modulated Signal Generator* — A signal generator, the output of which is amplitude modulated.

2.3 Frequency

2.3.1 *Frequency Drift* — The variation in the frequency at the output of the signal generator after the end of the warm-up period, for a specified period of time, under constant operating conditions.

2.3.2 *Frequency Band* — Part of the entire frequency range within which continuous variation of frequencies is provided.

2.3.3 *Frequency Range* — The frequencies covered by a signal generator continuously in which the signals produced meet all the requirements specified in this standard.

2.4 Output Voltage — The RMS value of the open-circuit voltage at the output terminals of a signal generator. This shall be expressed in microvolts or in millivolts.

2.4.1 *Residual Output Voltage* — The output voltage of the generator with all output controls turned to minimum position.

2.5 Modulation — The process in which any essential characteristics of a carrier wave is varied in accordance with a characteristic of another wave (modulating wave).

NOTE — Wherever modulation is mentioned in this standard it should be taken to refer to sinusoidal modulation only.

2.5.1 *Amplitude Modulation (AM)* — The type of modulation in which the amplitude of a carrier is varied in accordance with the amplitude of the modulating wave.

2.5.2 *Degree of Modulation (of an Amplitude Modulated Wave)* — The ratio of the *difference* of the maximum and minimum amplitudes of the wave to the *sum* of these amplitudes.

2.5.3 *Depth of Modulation* — Degree of modulation expressed as a percentage.

2.5.4 *Carrier Level Shift* — The fall in the mean carrier level of R.F. signal due to modulation applied.

2.5.5 *Unwanted Amplitude Modulation* — The amplitude modulation due to the noise and hum picked up by the oscillator circuit is termed as unwanted amplitude modulation. This is also known as *carrier noise* and the depth of this unwanted modulation is referred as *noise level.*

2.5.6 *Unwanted Frequency Modulation* — The unwanted change in the mean carrier frequency due to the application of amplitude modulation.

2.6 Distortion (Wave-Form) — The unwanted change in wave-form which can occur between two points in a transmission system.

2.6.1 *Distortion Factor* — Ratio of RMS voltage of all harmonics combined to the total RMS voltage.

2.6.2 *Percentage Distortion* — Distortion factor expressed as a percentage.

2.6.3 *Carrier Distortion* — Distortion of the wave-shape of the carrier signal. The effect of carrier distortion is the production of harmonics.

2.6.4 *Envelope Distortion* — Change in the sinusoidal wave-shape of the envelope of the modulated wave.

3. GENERAL CONDITIONS FOR MEASUREMENTS

3.0 Unless otherwise specified, measurements shall be made under normal measuring conditions as specified in 3.1 to 3.7.

3.1 Normal Supply Voltage — Rated voltage shall be applied to the generator.

3.1.1 In case of AC mains operation, the voltage shall be applied at the rated frequency.

3.1.2 The harmonic content of AC mains supply voltage shall not exceed 5·0 percent.

3.1.3 The operating mains voltage applied to the generator shall be held constant within ±2·0 percent of the rated value during the measurement of the characteristics.

3.1.4 In case of battery operation, primary or secondary batteries of the type and rated voltage as specified by the manufacturer, shall be used.

3.2 Modulation Frequency — For modulation measurements, the signal shall be modulated either internally or externally by a sinusoidal modulation frequency of 400 c/s or 1 000 c/s. The specific frequency chosen shall be stated in the test report.

3.3 Termination — The signal generator shall be suitably terminated with the specified load, wherever necessary.

3.4 Standard Atmospheric Conditions for Tests

3.4.1 Unless otherwise specified, all tests shall be carried out under the following atmospheric conditions:

Temperature	Between 15°C and 35°C.
Relative humidity	Between 45 percent and 75 percent.
Atmospheric pressure	Between 860 mbar and 1 060 mbar.

3.4.1.1 Where the conditions mentioned above have a significant influence, these shall be kept substantially constant during the tests.

3.4.2 If the temperature limits as given in **3.4.1** are too wide for certain tests, these tests shall be conducted/repeated in case of doubt, at a temperature of 27°C ± 1°C and relative humidity of 65 percent ±2 percent.

3.4.3 The instrument shall be protected from draughts and direct radiations.

3.5 Measurements

3.5.1 Measurements shall be made at least at one point, preferably middle, on each band.

3.5.2 All measurements shall be made after the initial warm-up period specified by the manufacturer.

3.6 Accuracy of Test Instruments — The test instruments employed to carry out measurements in accordance with this standard shall have an accuracy of at least one order higher than the instrument under test.

3.7 The test report should clearly indicate the following:

- a) Rated supply voltage,
- b) Atmospheric conditions under which tests are carried out, and
- c) Modulation frequency.

4. FREQUENCY MEASUREMENTS

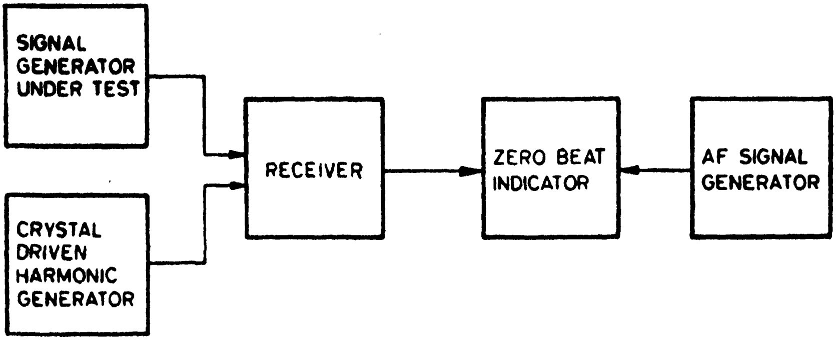
4.1 Frequency Calibration Error — The error in calibration of the frequency dial readings of a signal generator shall be checked at least at three points on each band, the position being taken at the beginning, middle and end of each band. The frequency of the signal generator shall be measured using a crystal driven harmonic generator as described in **4.1.1.** The measurements shall be done at 27°C ± 1°C.

4.1.1 *Measurement Using a Crystal Driven Harmonic Generator*

4.1.1.1 The signal generator output shall be made to beat with one of the harmonic signals of the crystal driven harmonic generator and the low frequency of the beat output signal shall be interpolated with an audio frequency generator.

4.1.1.2 The measuring accuracy is better than 0·01 percent at all those frequencies corresponding to the harmonics of the crystal calibrator since the crystal oscillator frequency is normally accurate to better than few parts in 10^6.

4.1.1.3 A schematic diagram of the set-up is given in Fig. 1.


SIGNAL GENERATOR UNDER TEST
CRYSTAL DRIVEN HARMONIC GENERATOR
RECEIVER
ZERO BEAT INDICATOR
AF SIGNAL GENERATOR

NOTE — Zero beat indicator includes a cathode ray oscilloscope.

FIG. 1 SCHEMATIC DIAGRAM FOR CHECKING FREQUENCY CALIBRATION ERROR USING CRYSTAL DRIVEN HARMONIC GENERATOR

4.1.1.4 Alternate methods for the measurement of frequency are given in Appendix A.

4.2 Frequency Drift

4.2.1 The frequency drift is calculated by measuring the frequency of the signal generator at specified intervals of time over a specified period by the method specified in **4.1.1**.

NOTE — The intervals and total period of time should be specified in the relevant requirement standard.

4.2.2 The supply voltage shall be kept constant within 1·0 percent and the ambient temperature at 27°C ± 1°C.

4.3 Frequency Change Due to Temperature — The measurements specified in **4.1.1** shall be repeated at different ambient temperatures at steps of 10 deg C over the range of specified operating temperature range. From these measurements the frequency change with temperature at various temperature steps shall be computed.

4.4 Frequency Change Due to AC Mains Voltage Variation — In case of AC operated signal generator, the mains voltage shall be varied from 220 V to 260 V in steps of 10 V. After maintaining the voltage at each step at least for one minute, the frequency of the signal generator shall be measured by the method specified in **4.1.1**. The change in frequency due to mains voltage variation shall be computed from these measurements.

4.5 Frequency Change Due to Load — The frequency of the generator shall be measured by the method specified in **4.1.1** with and without the rated output load connected to the generator, and with output setting at maximum. The change in frequency due to load shall be computed from these measurements.

4.6 Frequency Change Due to Modulation Applied — The frequency of the generator shall be measured by the method specified in **4.1.1** with and without modulation (to maximum possible depth) applied. The change in frequency due to modulation applied shall be computed from these measurements.

5. OUTPUT MEASUREMENTS

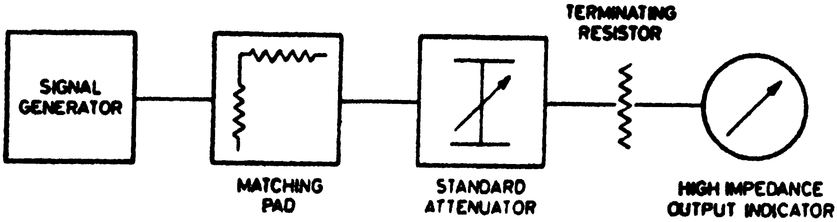
5.1 Measurement of Output Voltage

5.1.1 The signal generator shall be terminated by the specified load impedance and the highest R.F. voltage reference level shall first be established by measuring the output voltage by a suitable thermocouple millivoltmeter or a crystal millivoltmeter.

5.1.2 Having thus established the reference R.F. voltage, the accuracy of the calibration of the output markings shall be checked, using the set up consisting of the signal generator in series with a standard attenuator (*see* Fig. 2).

5.1.2.1 With the set up, readings corresponding to the change of position of output control of the signal generator shall be obtained in terms of change of position of the external calibrated attenuator as follows:

Turn the output control to the reference voltage. Introduce known attenuation with the help of the standard attenuator so



NOTE — The matching pad need be provided only in cases where the attenuator impedance is not the same as the load impedance of the signal generator.

FIG. 2 SET UP FOR THE MEASUREMENT OF OUTPUT VOLTAGE USING A STANDARD ATTENUATOR

that the output of the standard attenuator is not greater than the minimum calibrated output of the signal generator and note the deflection (D_1) on the output indicator. Cut out the standard attenuator and adjust the output control so as to bring the deflection on the output indicator to D_1. The output control marking shall be noted as against the attenuator marking of the standards attenuator. This process shall be repeated for various standard attenuator settings and output control markings.

5.1.3 The calibration of output control markings may be graphically represented so as to give a calibration chart of the output voltage of the signal generator.

5.1.4 This method is applicable for calibration at all levels of output voltage.

5.1.4.1 Alternate methods for measuring output voltage above 20 mV (bolometer method) and below 1 mV (substitution method) are described in Appendix B.

5.2 Measurement of Residual Output Voltage — The voltage at the output terminals of the signal generator with all output controls of the signal generator adjusted to the minimum position shall be measured in accordance with the method specified in **5.1**. The value measured corresponds to the residual output voltage of the signal generator.

5.3 Output Voltage Variation Due to Temperature — The measurements specified in **5.1** shall be repeated at different ambient temperatures at steps of 10 deg C over the specified temperature range. From these measurements, the output voltage variation with temperature shall be computed.

5.4 Output Voltage Variation Due to AC Mains Voltage Variation — In case of AC operated signal generator, the mains voltage shall be varied from 220 V to 260 V in steps of 10 V. The output voltage shall be

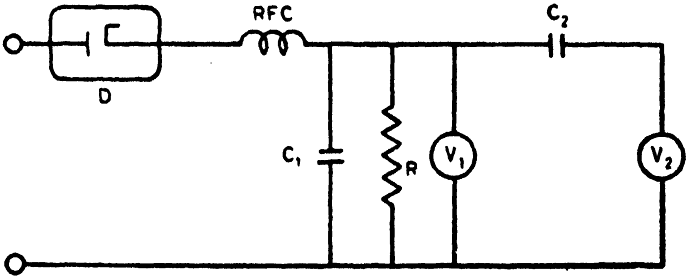
measured as specified in 5.1, after maintaining the voltage at each step for one minute at least. The change in output voltage due to mains voltage variation shall be computed from these measurements.

6. MODULATION MEASUREMENTS

6.1 Measurement of Degree of Modulation Using Linear Diode Detector

6.1.1 The circuit arrangement is shown in Fig. 3.

6.1.2 The modulation signal shall be rectified by a linear diode detector (*D*) having distortion less than 1·0 percent. The average value of the rectified voltage read by the DC millivoltmeter (V_1) shall give the carrier amplitude. The audio frequency voltage developed at the output of the detector (rectified component of the envelope of the modulated wave) shall be measured by a calibrated AC voltmeter (V_2).



D = Linear diode detector

C_1 = R.F. by-pass condenser (≏ 100pF)

C_2 = AF coupling condenser (≏ 0·5µF)

R = Diode load resistor (≏ 1 to 5 KΩ)

RFC = Radio frequency choke (≏ 2·5 mH)

V_1 = DC millivoltmeter

V_2 = Calibrated AC voltmeter

NOTE — Provision of a power amplifier ahead of diode would improve the sensitivity of the set up.

FIG. 3 SCHEMATIC DIAGRAM FOR MEASUREMENT OF DEGREE OF MODULATION USING LINEAR DIODE DETECTOR

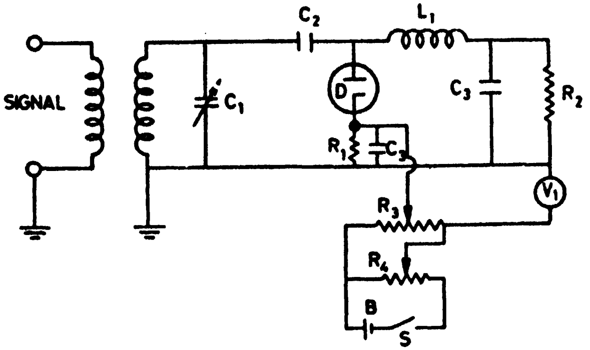
6.1.2.1 The degree of modulation is given by the ratio of the AC voltage (peak) (V_2) to the carrier amplitude (V_1).

6.1.3 This method assumes that the modulated envelope has distortion less than one percent.

6.1.4 Alternate method of measurement of modulation is given in Appendix C.

6.2 Method of Measurement of Carrier Level Shift

6.2.1 The circuit arrangement for measuring the carrier level shift is given in Fig. 4.



D = Diode (6AL5 or similar)
C_1 = Suitable tuning condenser
C_2 = R.F. coupling condenser (about 50 pF)
C_3 = R.F. by-pass condensers (about 100 pF)
R_1 = Cathode resistance (about 200 ohms)
R_2 = Plate load (about 47 K Ω)
R_3 = Fine control (about 100 K Ω)
R_4 = Coarse control (about 25 K Ω)
V = DC voltmeter (millivolts/microvolts range)
S = Switch
B = Battery 1·5 V
L_1 = R.F. choke (about 2·5 mH)

FIG. 4 SCHEMATIC DIAGRAM FOR MEASUREMENT OF CARRIER LEVEL SHIFT

6.2.2 The unmodulated signal is tuned in and the voltmeter is balanced out by the potentiometer R_3 and R_4. The carrier is then modulated at various degrees and the voltage (V_m) read on the voltmeter. With the modulation removed but without disturbing the potentiometer and with the switch 'S' open, the mean carrier voltage (V_c) is read on the voltmeter. The ratio of V_m to V_c expressed in percentage gives the carrier level shift at various degrees of modulation.

NOTE 1 — Voltage measurement across R_1 is made as this will not affect the operating conditions of the detector.

NOTE 2 — As V_m will be a small fraction of V_c and as V_c is of the order of a few millivolts, the meter shall be capable of reading millivolts and microvolts.

NOTE 3 — As the rectified voltage gets reduced with the carrier level shift, the deflection of the voltmeter may be in the opposite direction. A meter with centre zero is therefore preferred. Otherwise a double-pole double-throw switch will have to be used for changing the polarity of the meter.

6.3 Variation of Degree of Modulation Due to Temperature — The measurement described in **6.1** shall be repeated at different ambient temperatures at steps of 10 deg C over the specified temperature range. The variation of degree of modulation with temperature shall be computed from these measurements.

6.4 Variation of Degree of Modulation Due to AC Mains Voltage Variation — In case of AC operated signal generator, the mains voltage shall be varied from 220 V to 260 V in steps of 10 V. The degree of modulation shall be measured as specified in **6.1** after maintaining the voltage at each step for one minute at least. The change in degree of modulation due to mains voltage variation shall be computed from these measurements.

7. DISTORTION MEASUREMENTS

7.1 Measurement of Carrier Distortion — The unmodulated signal shall be fed to a heterodyne voltmeter or a calibrated radio receiver which shall be tuned to the fundamental as well as harmonics, and the output voltage at each of the frequencies shall be measured. The total sum of the harmonic voltages (without fundamental) and the total output voltage (fundamental + harmonics) shall be computed. Distortion factor shall be calculated from these values by the formula:

$$\text{Distortion factor, } K = \frac{\sqrt{E^2_2 + E^2_3 + \text{.........} E^2_n}}{\sqrt{E^2_1 + E^2_2 + E^2_3 + \ldots E^2_n}}$$

where

$E_1, E_2, E_3, \text{.........} E_n$ are the voltages at fundamental frequency, second harmonic, etc.

7.2 Measurement of Envelope Distortion — The modulated signal output of the generator shall be applied to a linear diode detector with minimum distortion and the distortion of the detected audio signal shall be measured by a distortion factor meter.

7.2.1 *Description of Distortion Factor Meter* — Distortion factor meter is an electronic device with which the amplitude distortion of an audio frequency signal can be measured quantitatively. It is basically a high gain amplifier with a filter network that balances to a sharp null at different frequencies, a calibrated attenuator to adjust the sensitivity and an electronic voltmeter. The measurement is effected by suppressing the fundamental component with a bridge type highly selective filter network and then comparing the amplitude of the residue with that of the total input. The null frequency is continuously variable in audio range. The distortion products are indicated directly on the panel meter. Distortion as low as one percent may be measured by this instrument.

8. MEASUREMENT OF UNWANTED MODULATION

8.1 Measurement of Unwanted Frequency Modulation — Under consideration.

8.2 Measurement of Unwanted Amplitude Modulation (or Carrier Noise) — The measurement of depth of unwanted amplitude modulation shall be carried out in the same manner as described in **6.1**, using a linear diode detector.

9. MEASUREMENT OF LEAKAGE

9.1 Radiation Leakage

9.1.1 The generator may radiate sufficient power to cause interference with the measurements. The radiation may be due to insufficient shielding of the generator.

9.1.2 This radiation leakage shall be measured with a calibrated radio receiver and a loop aerial system. A schematic diagram of the set up is shown in Fig. 5.

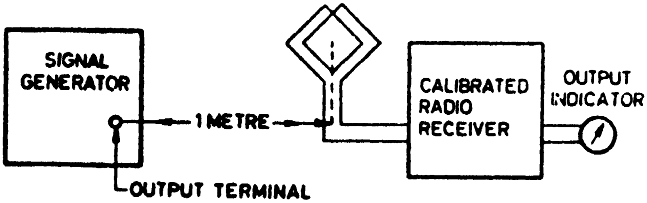


FIG. 5 SCHEMATIC DIAGRAM FOR MEASUREMENT OF RADIATION LEAKAGE

9.1.3 The voltage induced in the loop aerial due to radiation is given by the equation:

$$E = \frac{2\pi \varepsilon N A}{\lambda}$$

where

E = induced voltage in the loop antenna,
ε = field strength in volts per metre,
N = number of turns in the loop,
A = area of loop (in square metres), and
λ = wave length of measuring frequency (in metre).

9.1.4 The centre of the loop aerial shall be kept one metre away from the generator outlet terminated by its rated impedance. The loop aerial shall be connected to a radio receiver whose output is calibrated in terms of aerial input. The receiver shall be tuned to the signal generator frequency and the receiver output is measured at various positions of the generator under test, the loop aerial being turned to the position of maximum reception. The level of radiation shall be computed using the equation given in 9.1.3.

NOTE — The measurement of radiation leakage should be carried out taking care to avoid external interference.

9.1.5 In measuring the radiation leakage from the signal generator care should be taken to ensure that the terminations and connecting leads or cables do not contribute to the measured radiation picked up by the receiver.

9.2 Supply Lead Leakage

9.2.1 The R.F. power leakage in a signal generator may be through the power supply leads.

9.2.2 The supply lead leakage shall be measured with a calibrated radio receiver.

9.2.2.1 A schematic set up is shown in Fig. 6.

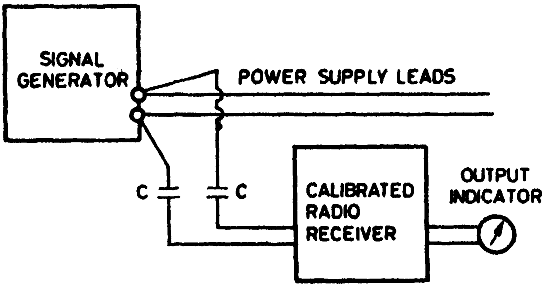


FIG. 6 SCHEMATIC DIAGRAM FOR MEASUREMENT OF SUPPLY LEAD LEAKAGE

9.2.2.2 A calibrated radio receiver shall be connected to the power supply input terminals of the signal generator through a pair of coupling condensers and the supply lead leakage is measured directly.

10. MEASUREMENT OF NOMINAL SOURCE IMPEDANCE

10.1 The output voltage of the signal generator shall be measured with an electronic voltmeter on open circuit. The output shall then be terminated by a variable resistance of negligible reactance. The terminating resistance shall be adjusted till the output voltage is equal to half the value on open circuit. The value of the resistance shall be a measure of the modulus of the source impedance. The measurement should be repeated as a function of frequency over the specified frequency range.

APPENDIX A

(*Clauses* 0.4 *and* 4.1.1.4)

ALTERNATE METHODS FOR MEASUREMENT OF FREQUENCY

A-1. MEASUREMENT USING ELECTRONIC FREQUENCY COUNTER

A-1.1 The signal generator shall be terminated by its rated output impedance; the output from signal generator shall be fed to the input of electronic frequency counter and the frequency read out directly.

A-1.1.1 The measuring accuracy of the counter is better than 0·01 percent ± 1 c/s.

A-1.2 A suitable frequency converter may be used when the frequency to be measured is above the range of the main counter.

A-1.3 Description of Electronic Frequency Counter — The electronic frequency counter is an instrument designed for measurement of the number of events or vibrations of an oscillator per unit time. This instrument directly counts the number in cycles per second and displays them on a digital type indicator. The principle of operation is that an initial measurement of the number of vibrations is carried out over a fixed period of one second or a decimal multiple of it and the resultant is appropriately displayed on a series of decade scaler units.

A-1.3.1 The unknown frequency is normally applied through a wide band squaring amplifier to a fast electronic gate controlled by a precision time base generator. When the gate is opened, the signal under measurement is fed to a series of digital type decade counters which record each cycle of the operating frequency. When the gate closes, after a fixed unit of time, the counting is stopped and the total count is displayed. The display is kept on for a short time to enable the read-out till the time base generator resets the counting circuits to zero and opens the gate again for the next measurement.

A-1.3.2 The range of instrument is normally 0 to 10 Mc/s. For the measurement of frequencies above 10 Mc/s, a suitable frequency converter may be utilized with the main counter unit.

A-1.3.3 The electronic frequency counter is a simple and reliable method of measuring the frequency of oscillator with high precision and exceptional speed. The accuracy of the instrument is ±2 parts per million plus one count; the former figure stands for the accuracy of the crystal used and the latter is the inherent tolerance which occurs due to the possible random phasing of the measured frequency with respect to the arbitrary gate time.

A-2. MEASUREMENT USING HETERODYNE FREQUENCY METER

A-2.1 The simplest method of frequency calibration is by using a heterodyne frequency meter. The output of the signal generator is caused to beat with the fundamental or harmonic of a variable frequency oscillator for zero beat and the exact frequency determined.

A-2.2 Description of Heterodyne Frequency Meter — The heterodyne frequency meter is a calibrated stable variable frequency oscillator coupled with a detector and an amplifier. The variable frequency oscillator normally maintains its calibration to better than 0·1 percent over long periods.

APPENDIX B

(*Clauses* 0.4 *and* 5.1.4.1)

ALTERNATE METHODS FOR MEASUREMENT OF OUTPUT VOLTAGE

B-1. BOLOMETER METHOD

B-1.1 General — Bolometer bridge method described is capable of measuring R.F. voltages above 20 mV and up to 700 Mc/s with an accuracy of one percent or better. Radio frequency voltages lower than 20 mV may also be measured by this method, however, with the sacrifice of accuracy in measurements.

B-1.1.1 *Principle* — The basic principle in measuring R.F. voltage by a bolometer bridge consists briefly of balancing a DC Wheatstone bridge having a bolometer in one of its arms and of rebalancing it again after part of the DC voltage is substituted by R.F. voltage required to be measured. The difference in the DC voltage gives a precise indication of R.F. voltage applied as the resistance of the bolometer element employed depends only on the total power dissipation in it irrespective of its nature whether it is DC or AC.

B-1.2 Bolometer Bridge

B-1.2.1 A schematic of a typical bolometer bridge incorporating two thermistor elements of equal resistances is given in Fig. 7.

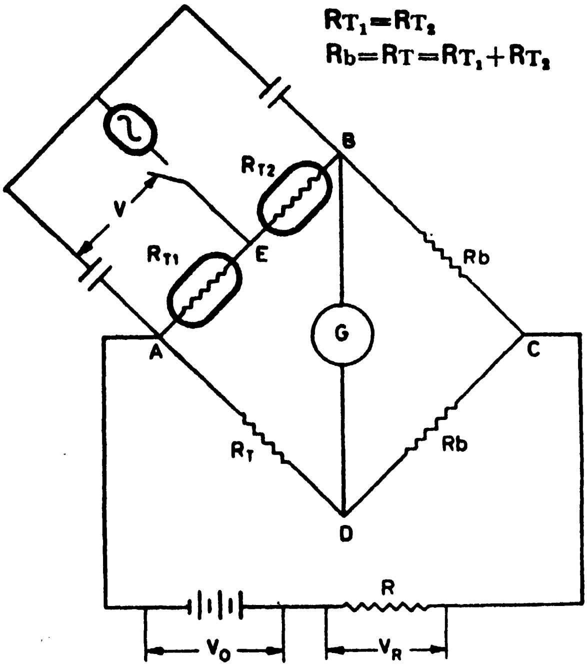


FIG. 7 BOLOMETER BRIDGE FOR THE MEASUREMENT OF OUTPUT VOLTAGE

B-1.3 Procedure — The bridge is first balanced without R.F. energy applied across the thermistor terminals and with no resistance in series with the battery. The power consumed in the thermistor arm will then be $V_O^2/8R_{T_1}$, where V_O is the battery voltage and R_{T_1} is the resistance of individual thermistor element. The R.F. voltage to be measured is then applied symmetrically across the thermistors as shown in the figure, simultaneously reducing the battery voltage by introducing the series resistance R. Balance is restored by adjusting the value of R. Voltage drop (V_R) across the series resistance is measured. The thermistor bridge is now supplied by the following two sources:

a) R.F. voltage to be measured, and

b) Reduced battery voltage ($V_O - V_R$).

The reduction in the battery power is compensated by the R.F. power supplied. If V is the unknown R.F. voltage then it can be shown that $V = \frac{1}{2}\sqrt{V_R(2V_O - V_R)}$.

B-1.4 Factors Limiting the Performance of the Bridge

B-1.4.1 The upper limit of the voltage range is limited by thermistor characteristics in a given mount. Voltages as high as 10 V can be measured by choice of thermistors and mounts.

B-1.4.2 The lower limit of the voltage range is dependent on the following factors:

a) Sensitivity of the thermistors and of the bridge,

b) Ease with which low values of V_R can be adjusted and measured,

c) Stability and accuracy of V_O,

d) Thermal voltages and incidental voltage drops in circuit leads and connections, and

e) Ambient temperatures.

NOTE — To minimize errors due to ambient temperature variations, the measurements should be made in an air-conditioned room. The errors contributed by thermal voltages and incidental voltage drops in circuit leads and connections as well as due to ambient temperature variations of 0·5 deg C are negligible in comparison to other errors.

B-1.4.2.1 The total error in measurements contributed by all factors assuming that all individual errors are cumulative, does not exceed 0·8 percent. An extension of measurement range below 20 mV without sacrificing accuracy will require first improvement of stability of battery voltage as well as improvement in measurement of voltage across the resistance in series with the battery.

B-1.5 A typical set up is described in " A Bolometer Bridge for Standardising R.F. Voltmeter " by Selby, M. C., and Behrent, L. F., published in the Journal of Research of National Bureau of Standards, USA, Vol 44, January 1950.

B-2. SUBSTITUTION METHOD

B-2.1 When the level of output voltage is less than one millivolt, a substitution method using a standard signal generator and a calibrated radio receiver shall be employed as described in **B-1.1.1** to **B-1.1.4**.

B-2.1.1 The signal of a known amplitude and frequency from a standard signal generator shall be fed to a radio receiver tuned to the generator (standard) frequency and the output voltage across the second detector of the receiver with AVC line disconnected, shall be measured with the output indicator. This indicator shall thus be calibrated in terms of the various output settings of the standard signal generator.

B-2.1.2 The signal generator under test, adjusted to the same frequency, shall then be substituted in place of the standard signal generator. The output settings of the generator shall be checked with respect to the readings obtained on the calibrated radio receiver.

NOTE — The measurement of output voltage of the signal generator under test shall be repeated to ensure that no drift has occurred in the receiver.

B-2.1.3 In these measurements care should be taken to see that the loading due to the receiver input impedance will be such that the effective output of the signal generator is not altered by more than 1·0 percent.

B-2.1.4 The standard signal generator shall have the same output impedance as the signal generator under test. Alternatively, suitable matching networks shall be interposed between the receiver and the signal generator for purposes of matching.

B-2.1.5 A schematic diagram of the set up is shown in Fig. 8.

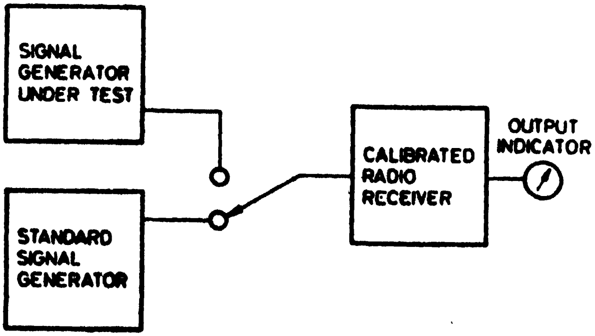

SIGNAL GENERATOR UNDER TEST
STANDARD SIGNAL GENERATOR
CALIBRATED RADIO RECEIVER
OUTPUT INDICATOR

FIG. 8 SCHEMATIC DIAGRAM FOR MEASUREMENT OF OUTPUT VOLTAGE BY SUBSTITUTION METHOD

B-2.2 Description of Standard Signal Generator — A standard signal generator is an oscillator calibrated to provide output signals of precisely known frequency and voltage. It consists of a radio frequency oscillator of good inherent stability, a buffer amplifier, a modulator and a calibrated attenuator. The output signal has good wave-form and negligible noise or hum. The signal amplitude is continuously variable and is read with a calibrated electronic voltmeter. The instrument is capable of being modulated up to 100 percent with low incidental frequency modulation. An internal crystal calibrator is incorporated within the instrument for the frequency calibration checking.

APPENDIX C

(*Clauses* 0.4 *and* 6.1.4)

ALTERNATE METHOD FOR MEASUREMENT OF MODULATION

C-1. MEASUREMENT OF DEGREE OF MODULATION USING CATHODE RAY OSCILLOSCOPE

C-1.1 The modulated signal is fed to the vertical plates of a cathode ray oscilloscope, the time base of which is adjusted to synchronize with the modulating signal so that a steady pattern consisting of at least two cycles of the modulated wave-form appears on the screen.

C-1.2 The extent of modulation is examined visually and the crest and trough heights are measured with a transparent scale.

C-1.3 The degree of modulation is computed from the equation:

$$\text{Degree of modulation, } m = \frac{E_{max} - E_{min}}{E_{max} + E_{min}}$$

where

E_{max} = peak to peak amplitude of the crest (*see* Fig. 9), and
E_{min} = peak to peak amplitude of the trough (*see* Fig. 9).

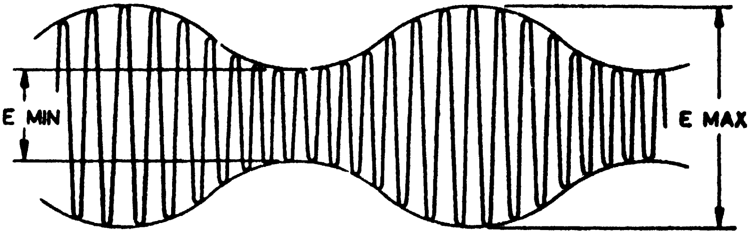


FIG. 9 MODULATED WAVE AS OBSERVED ON A CATHODE RAY OSCILLOSCOPE

C-1.4 Description of Cathode Ray Oscilloscope — The cathode ray oscilloscope is an instrument designed for the analysis of electrical circuits by a study of the wave-forms of voltages and currents at various points, within the limits of its frequency response characteristics. The basic elements of an oscilloscope are a cathode ray tube, vertical and horizontal amplifiers, a saw tooth sweep generator and the requisite power supplies. The instrument may be employed to observe the sinusoidal wave-form of audio and radio frequency signals by feeding the input signals to the vertical amplifiers and a saw tooth shaped signal of frequency equivalent to a sub-harmonic of the input frequency to the horizontal plates. Lissajous patterns may also be observed on the screen when two signals whose frequencies are in an integral ratio, are fed to the vertical and horizontal plates respectively.

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